STIS MAMA Reconfigurations

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ABSTRACT
This Instrument Science Report describes the requirements for STIS MAMA reconfigurations. The conditions under which MAMA HV shutdown can occur are reviewed and the procedures for analyzing and then recovering from a MAMA HV shutdown are summarized. The report does not discuss the technical aspects of how the Standard and Anomalous high voltage switch-on procedures are implemented.

1. Introduction
STIS has two MAMA detectors for ultraviolet spectroscopy and imaging. In this ISR we will discuss the operating rules for MAMA detectors and review the conditions under which a MAMA detector can be shutdown or temporarily shuttered, together with the rules and procedures to be followed in recovering after a high voltage shutdown, or a local rate monitor violation. The document is organized as follows:

Section 2: The requirements for MAMA operations.
Section 3: MAMA operating configurations
Section 4: Conditions under which a MAMA HV shutdown will occur.
Section 5: Procedures for recovering from a MAMA HV shutdown.
Section 6: MAMA bright object violation diagnostics
Section 7 Procedures for analysis of a local rate monitor violation
Section 8: Procedures for recovery from a MAMA high voltage shutdown.

2. Requirement for MAMA operations
The STIS team have established the primary operating requirement for MAMA detectors in a report written by John Loiacano (680-STIS-MAMA-001). This report is a trade study to determine whether the MEB and MAMA subsystems would be more reliable if they were turned off during SMS’s, or left operational all the time. It concludes that the
MAMA’s and their subsystems should be maintained in a fully powered state all the time, except when STIS or the telescope safes, and when it is essential to take the instrument to the hold state. The report identifies MAMA tube stress, due to rapid changes in the high voltage, as a potential source of detector degradation. Consequently, every MAMA high voltage shutdown should be a slow ramp down, except in cases where the high voltage needs to be pulled down instantaneously to protect the Science Instrument. Similarly, the high voltage should always be ramped up slowly during MAMA high voltage switch-on. These requirements are formally specified as STIS Restrictions 3.4.9.4 “STIS Rapid turn-off of MAMA High Voltage” and 3.4.9.5 “Minimize MAMA High Voltage Cycles”.

3. MAMA operating configurations.

Hold
In the MAMA hold state the MAMA detector voltages and signal processing electronics are all powered down.

Operate
In the MAMA operate state the MAMA detector voltages and signal processing electronics are all operating at their nominal values. From the initiation of Hold to Operate, until the MAMA is returned to Hold, the MAMA bright object protection rules, for detector shuttering, should be in force, to ensure that the detector is always protected from the possibility of overillumination. The hardware and software bright object monitors become active at different stages of the MAMA Hold to Operate sequence. The Bright Scene Detection (BSD) hardware is active from the initiation of Hold to Operate, while the Global Software Monitor (GSM) is only enabled, by stored commanding, once the high voltage ramp has been successfully completed.

The MAMA detector’s high voltage should not be turned on if the HST will enter the SAA at any point during the process of ramping up the high voltage.

There is a restriction on turning on the MAMA high voltage which requires that the voltages are always ramped up to their nominal operational values slowly using a predefined rate.

There is a restriction on turning off the MAMA high voltage which requires that the voltages are always ramped down to zero slowly using a predefined rate.

Standby
In MAMA standby state the MAMAs power supplies have been ramped up to their normal operating values, but the charge amplifiers are turned off. In this configuration the MAMA is unprotected from over-illumination. Consequently, the MAMA standby state should
never be used in-orbit since there is the potential for permanent damage. Historically, this instrument state was intended to minimize power consumption, thus alleviating thermal control issues, but following the STIS thermal redesign, this is no longer required.

4. MAMA Shutdowns

The high voltage (HV) for the STIS MAMAs can be shut down autonomously as a result of a number of spacecraft and STIS safety features.

Safemode entry.

_HST or NSSC-I safing._

Due to the requirement to keep the MAMA HV on all the time, the STIS will have MAMA HV up, and may be using the MAMAs for science observations, whenever the HST goes into a vehicle safemode or when the NSSC-I initiates a payload safing. There will certainly be some system safemode responses which will abruptly shut off the MAMAs.

None of the system safemode entries can be caused by problems with the STIS MAMAs, either internal or induced by bright objects. The presumption in the event of a system safemode entry will be that there has been no failure or problem with the MAMAs. When available, engineering data will be reviewed to verify that nothing unusual occurred with the STIS MAMAs during safemode entry. If such data is not available, it will be assumed that no damage has occurred to the MAMAs and that they can be bought up using the standard slow voltage ramp procedure.

System safemodes entries will halt the entire HST timeline. A recovery SMS is required to return all SIs to their proper state and re-initiate the observing timeline. In these events, the STIS instrument and the MAMAs will be returned to normal operations by the STScI via stored commanding in the recovery SMS, there being no advantage in these cases to real-time recoveries.

_STIS instrument safing_

The STIS can be individually safed by the NSSC-I, if the NSSC-I detects conditions indicating improper STIS operation. The NSSC-I monitors STIS voltages, temperatures, and microprocessor activity. There are no safing actions which are directly related to MAMA operations or bright objects.

In the event that the NSSC-I has safed the STIS, then analysis will be required to determine the cause of the safing. Status buffer messages and engineering telemetry around the time of the safing will be reviewed, as will the commanding for the period around the safemode entry. Recovery of the STIS from safemode will not be initiated until there is an
understanding of the reason for the safing, and corrective action taken. In the event that the analysis indicates that there is a possible problem with STIS hardware, then a further analysis will be required to determine whether the potential problem would place the MAMAs at additional risk when they are returned to operation. If there is any doubt about continued MAMA safety, they will be left off when STIS is recovered to Hold state, and potentially to CCD operate state. (As an example, an MIE computer malfunction might allow further safe CCD observing, but be a danger to MAMA operations.)

Once the problem has been identified, the STIS will be brought from Safe to Hold and then to the operate state. Given the analysis time, this activity will be done via stored commanding at the next SMS boundary. In circumstances when the reason for the safemode is quickly identified and clearly not a reason for further safety concern, the STScI and MOSES may elect to return the STIS and MAMAs to operation via real-time commanding.

**Suspend**

The STIS flight software has the ability to suspend operations, rather than safe, under some circumstances. This has the advantage of leaving the contents of the STIS computer memory intact, so a memory dump may help determine details of the problem. There is a flight software table which identifies all error conditions which will lead to the SUSPEND state. Any time the STIS enters a suspend state, one of the first steps will be to capture and analyze a memory dump. Error conditions in which there is no immediate danger to the detector, will lead to a “slow SUSPEND”, in which the detector high voltage is ramped down slowly.

*MAMA related SUSPEND entry*

There are currently seven MCE related reasons for entry into SUSPEND state, identified via individual status buffer entries. In all cases, these indicate a hardware problem with the MCE, and would require an extended analysis and debug period. During this period, STIS CCD operations might be carried out, but the affected MAMA would not be used.

*Other SUSPEND entries*

The STIS can go into SUSPEND state for reasons having nothing to do with the MAMAs. In these cases, an analysis of the reasons for the entry into SUSPEND must be completed before returning the STIS and the MAMAs to operations. As a part of the analysis, we will determine whether the problem causing the SUSPEND entry indicates the possibility of a weakness in the on-board protection of the MAMAs. If so, the MAMAs will not be returned to operations until the weakness is rectified, although conceivably the CCDs could be used.
5. Recovery from MAMA detector high voltage shutdown

Standard Recovery procedure
The standard procedure for recovering from a high voltage shutdown is to slowly ramp up the high voltage.

Anomalous Recovery procedure
If it is believed that there may have been damage to a MAMA detector, either as a result of a hardware problem, or due to a bright object violation then the detector has to be switched back on using the Anomalous Recovery Procedure. This procedure is currently in the process of definition and will be described elsewhere.

6. MAMA bright object violation diagnostics
The following diagnostics are available to evaluate the cause of a MAMA detector problem resulting from over-illumination of the detector:

- Engineering telemetry
  A summary of engineering telemetry items for MAMA bright object protection in the STIS header packet is presented in Table 1. In addition to MAMA BOP keywords, the telemetry should be reviewed to generate a snapshot of the instrumental configuration when the problem occurred. The MSM encoder values should also be checked to ensure that the commanded optical element was in place, and that the specified aperture had been correctly selected.

Table 1. Summary of Bright Object Monitor telemetry in STIS header packet.

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Title</th>
<th>Rate</th>
<th>Bits</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCAL RATE MONITOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM1ELEX</td>
<td>MIE local event rate limit check result (FUV MAMA)</td>
<td>30 s</td>
<td>1</td>
<td>0 = Local OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Local detected</td>
</tr>
<tr>
<td>OM1EJEMX</td>
<td>MIE local event monitor check status (FUV MAMA)</td>
<td>30 s</td>
<td>1</td>
<td>0 = Local check not active</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Local check active</td>
</tr>
<tr>
<td>OM2ELEX</td>
<td>MIE local event rate limit check result (NUV MAMA)</td>
<td>30 s</td>
<td>1</td>
<td>0 = Local OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Local detected</td>
</tr>
<tr>
<td>OM2EJEMX</td>
<td>MIE local event monitor check status (NUV MAMA)</td>
<td>30 s</td>
<td>1</td>
<td>0 = Local check not active</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Local check active</td>
</tr>
<tr>
<td>GLOBAL SOFTWARE MONITOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM1GLBX</td>
<td>FUV Mama global monitor status (FUV MAMA)</td>
<td>10 s</td>
<td>1</td>
<td>0 = No Global check</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Global check active</td>
</tr>
</tbody>
</table>
• **Status buffer messages**

Status buffer messages provide an indication of the instrument problem which occurred. Specific status buffer messages relevant to MAMA bright object protection are summarized in Table 2. These messages are all indicative of an event rate violation, except FSW#131 which flags a violation of the MCP current limit. It is included because it is possible for major violations of the global count rate limit to cause a current sag, resulting in an out of limit condition. It should be noted that this has never been observed in ground testing.

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Title</th>
<th>Rate</th>
<th>Bits</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM1GEEX</td>
<td>FUV Mama global event error (FUV MAMA)</td>
<td>60 s</td>
<td>1</td>
<td>0 = No Error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Error</td>
</tr>
<tr>
<td>OM1ECTX</td>
<td>FUV Mama event count threshold status (FUV MAMA)</td>
<td>60 s</td>
<td>1</td>
<td>0 = OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Exceed</td>
</tr>
<tr>
<td>OMA1GTHR</td>
<td>FUV Mama global threshold (FUV MAMA)</td>
<td>60</td>
<td>16</td>
<td>Counts/Integration</td>
</tr>
<tr>
<td>OM1EVX</td>
<td>FUV Mama event type (FUV MAMA)</td>
<td>10</td>
<td>8</td>
<td>VE, W, X, Y, Z, EV, OR</td>
</tr>
<tr>
<td>OM1EVQ</td>
<td>FUV Mama event count (FUV MAMA)</td>
<td>10</td>
<td>16</td>
<td>Counts/Integration</td>
</tr>
<tr>
<td>OM1GEVIP</td>
<td>FUV Mama global event integration period (FUV MAMA)</td>
<td>60</td>
<td>12</td>
<td>millisec</td>
</tr>
<tr>
<td>OM2GLBX</td>
<td>NUV Mama global monitor status (NUV MAMA)</td>
<td>10</td>
<td>1</td>
<td>0 = No Global check</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Global check active</td>
</tr>
<tr>
<td>OM2GEEX</td>
<td>NUV Mama global event error (NUV MAMA)</td>
<td>60 s</td>
<td>1</td>
<td>0 = No Error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Error</td>
</tr>
<tr>
<td>OM2ECTX</td>
<td>NUV Mama event count threshold status (NUV MAMA)</td>
<td>60 s</td>
<td>1</td>
<td>0 = OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Exceed</td>
</tr>
<tr>
<td>OMA2GTHR</td>
<td>NUV Mama global threshold (NUV MAMA)</td>
<td>60</td>
<td>16</td>
<td>Counts/Integration</td>
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<tr>
<td>OM2EVX</td>
<td>NUV Mama event type (NUV MAMA)</td>
<td>10</td>
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<td>VE, W, X, Y, Z, EV, OR</td>
</tr>
<tr>
<td>OM2EVQ</td>
<td>NUV Mama event count (NUV MAMA)</td>
<td>10</td>
<td>16</td>
<td>Counts/Integration</td>
</tr>
<tr>
<td>OM2GEVIP</td>
<td>NUV Mama global event integration period (NUV MAMA)</td>
<td>60</td>
<td>12</td>
<td>millisec</td>
</tr>
<tr>
<td>OM1BSDX</td>
<td>FUV MAMA bright scene detected (FUV MAMA)</td>
<td>60</td>
<td>1</td>
<td>0 = OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Bright</td>
</tr>
<tr>
<td>OM1OVRX</td>
<td>FUV MAMA bright scene detection override disable (FUV MAMA)</td>
<td>60</td>
<td>1</td>
<td>0 = Disable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Enable</td>
</tr>
<tr>
<td>OM2BSDX</td>
<td>NUV MAMA bright scene detected (NUV MAMA)</td>
<td>60</td>
<td>1</td>
<td>0 = OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Bright</td>
</tr>
<tr>
<td>OM2OVRX</td>
<td>NUV MAMA bright scene detection override disable (NUV MAMA)</td>
<td>60</td>
<td>1</td>
<td>0 = Disable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = Enable</td>
</tr>
</tbody>
</table>
Table 2. Status buffer messages relevant to MAMA operations

<table>
<thead>
<tr>
<th>FSW #</th>
<th>NSSC-I #</th>
<th>Error Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>111</td>
<td>623</td>
<td>MIE_EVENT_RATE_CMD_FAILED</td>
</tr>
<tr>
<td>112</td>
<td>624</td>
<td>MIE_EVENT_RATE_STATUS_FAILURE</td>
</tr>
<tr>
<td>113</td>
<td>625</td>
<td>MIE_EVENT_THRESHOLD_EXCEEDED</td>
</tr>
<tr>
<td>129</td>
<td>641</td>
<td>MIE_SECOND_EVENT_THRESHOLD_EXCEEDED</td>
</tr>
<tr>
<td>131</td>
<td>643</td>
<td>MAMA_MCP_CURRENT_LIMIT</td>
</tr>
<tr>
<td>135</td>
<td>647</td>
<td>MCE1_BRIGHT_SCENE_DETECTED</td>
</tr>
<tr>
<td>137</td>
<td>649</td>
<td>MCE1_EVENT_THRESHOLD_EXCEEDED</td>
</tr>
<tr>
<td>140</td>
<td>652</td>
<td>MCE2_BRIGHT_SCENE_DETECTED</td>
</tr>
<tr>
<td>142</td>
<td>654</td>
<td>MCE2_EVENT_THRESHOLD_EXCEEDED</td>
</tr>
</tbody>
</table>

- **Command sequence executed**
  The relevant command sequence in the SMS which was executing when the problem occurred should be reviewed.

- **Review proposed science observation**
  If a bright object violation occurred, the proposed science observation should be reviewed to determine why a bright object condition occurred. This involves simulating the observation to determine the global count rate and the peak local count rate for the specified observing configuration.

- **High voltage ramp-up diagnostics**
  Whether the MAMA high voltage is brought up using the standard procedure or the anomalous recovery procedure, the telemetry is generated during the process and can be used to assess the MAMA detector’s state of health.

- **Post-Recovery Diagnostics**
  If required, post-recovery diagnostics should be executed. The primary diagnostic for the MAMA detector is the MAMA mini-functional test. If there is uncertainty regarding why the bright object violation occurred it may be necessary to obtain a verification exposure of the target in question to determine the true global and peak local count rates. The observations may be made with STIS using a neutral density filter or narrower slit, or a different instrument such as WFPC2.

7. Procedures for analysis of a local rate monitor violation

*Local rate check violation*

A local rate violation is easily identified since the detector remains shuttered and the high voltage is not shut down. The procedure to be followed in such a case is summarized in Figure 1. The key elements of this procedure are:
• **Review diagnostics:** The available diagnostics should be reviewed to confirm a local rate violation. A status buffer error message will have been sent

  FSW#113 - MIE_EVENT_THRESHOLD_EXCEEDED,

  The flight telemetry flags for the local rate monitor, summarized in Table 1, are set. The observing configurations sent to the instrument in the SMS should be reviewed and compared to the engineering telemetry to determine whether the violation might have resulted from an anomalous instrument configuration, such as an incorrect MSM position or the incorrect optical element.

• **Analyze local rate image:** The local rate image should be analyzed to determine the severity of the local rate violation.

• **Review science observation:** The science observation should be reviewed in the light of data from the local rate image to determine how bright the target was, why a violation occurred, and why it was missed by the screening procedures. If it is determined that there is a problem in the current screening procedures then a change may be recommended. If the reason for the violation can not be determined, an observation of the target, with an alternative STIS observing configuration or, with another instrument, should be considered. During early operations with STIS it will be important to understand the reason for every local rate violation, in order to monitor the success of the proposal screening for bright objects.

• **Determine severity of over-illumination:** If the local rate violation can be shown to have resulted in no damage, because the peak input count rate was <10^3 counts/sec/pixel, then no action should be taken. The next scheduled MAMA mini-functional and flat fields should be reviewed to ensure that there was no significant quantum efficiency loss (>1%), in the region of the image where the violation occurred. If there is reason to believe that the peak local count rate level exceed 10^3 counts/sec/pixel, it is possible that there may be >1% DQE loss and a replan should be considered, so that diagnostic tests can be executed.
8. Procedures for recovery from a MAMA high voltage shutdown

**HV shutdown: Global count rate violation**

A global count rate violation currently results in an immediate shutdown of the MAMA detector’s high voltage. When such a shutdown occurs, the first question to be answered is whether the shutdown occurred from a global rate violation, or from some other unrelated problem. The status buffer messages and telemetry keyword permit a global rate violation to be identified and the two cases, bright scene detection and global software monitor to be distinguished.
**Bright Scene Detection**

A high voltage shutdown resulting from triggering the Bright Scene Detection, is identified from the status buffer messages:

- FSW#135 - MCE1_Bright_Scene_Detected (MAMA 1)
- FSW#140 - MCE2_Bright_Scene_Detected (MAMA 2)

The 60 second update rate is too slow for the telemetry to record a bright scene detection violation and so telemetry will provide no additional useful information.

**Software Global Software Monitor**

A high voltage shutdown resulting from triggering the global software trigger, is identified from the status buffer messages:

- FSW#137 - MCE1_Event_Threshold_Exceeded (MAMA 1)
- FSW#142 - MCE2_Event_Threshold_Exceeded (MAMA 2)

The engineering telemetry keyword OMIGEEX, or OM2GEEX is latched and permits additional confirmation that the shutdown was caused by the global software monitor.

**Decision tree**

The procedure to be followed in the event of a MAMA HV shutdown is presented in Figure 2. The key elements of the procedure are:

- **Review diagnostics:**
  - The available diagnostics should be reviewed to diagnose the nature of the global rate violations (see “Bright Scene Detection” on page 10. and “Software Global Software Monitor” on page 10.). The observing configurations sent should be reviewed and compared to the engineering telemetry to determine whether the violation might have resulted from an anomalous instrument configuration, such as an incorrect MSM position or optical element.
  - If the telemetry and status buffer messages are not consistent with a global rate violation, it is likely that a hardware problem has occurred. Hardware problems will need to be reviewed on a case by case basis, and no attempt should be made to bring the detector’s HV back up pending a full review of the problem and instrument status.

- **Review proposed science observation:**
  - The proposed science observation should be reviewed in the available data to determine how bright the target was, why a violation occurred, and why it was missed by the screening procedures. If it is determined that there is a problem in the current screening procedures then a change in the current procedures may be recommended. If the reason for the violation can not be determined, an observation of the target, with an alternative STIS observing configuration or, with another instrument, should be considered. During early operations with STIS it will be important to understand the reason for every global rate violation.

- **Bright Object Review Panel**
  - Every MAMA detector HV shutdown will have to be reviewed by a Hardware Review Panel before the detector can be brought back up. The mandate of the panel will be to...
review the available information on the MAMA HV shutdown and recommend a course of action. The primary issue to be considered during the review is whether damage could have occurred to the detector. If there is a possibility of detector damage, then the anomalous HV ramp-up procedure should be employed. The bright object CARD item currently states that permanent damage to the detector can occur if it is subjected to a count rate of $1.5 \times 10^6$ counts/sec for $\geq 1$ second. The global software monitor triggers at the level of $7.7 \times 10^5$ OR counts/sec, which corresponds to an input OR count rate of $10^6$ counts/sec. The decision required, therefore, is whether the detector has approached the card limit prior to shut down. Since a Bright Scene or Global Software monitor shutdown produces no telemetry indicating the actual rate leading to the shutdown, the worst case should be assumed unless it can be clearly demonstrated by simulation that the CARD has not been exceeded.

**Suspend**

If the STIS suspended due to a non-MAMA related problem, and the diagnostic analysis indicates no system risk then a normally recovery can be initiated. If STIS suspended due to a MAMA_1 related problem, one of following status buffer messages will be result:

- FSW#43, NSSC1#555 MCE_HVOFF_PROBLEM
- FSW#136, NSSC1# 648 MCE1_WATCHDOG_TIMEOUT
- FSW#138, NSSC1# 650, MCE1_RAM_TEST_FAILED
- FSW#139, NSSC1# 651, MCE1_CHECKSUM_FAILED

A similar set of messages are produced for MAMA-2 (FSW 141, 143, 144). These errors indicate MCE problems which are not related to the MAMA detector. They indicate a communication problem between the CS and MCE. It would occur if a voltage limit problem had been detected and the CS could not command the MCE to turn the HV off. In this case the MCE should be tested to see if it responds to NOOP commands. A signal processing electronics check should be done to verify the amplifier noise levels with the HV off. If these tests are successful then it is possible to proceed with a normal HV ramp, since it was not a tube anomaly responsible for the HV shut down. It should be noted that suspending as a result of these errors will bring BOTH MAMA HV’s down. The MAMA on the side that did not show MCE anomalies may be ramped back up normally.

**Safe**

If the STIS safed due to a non-MAMA related problem, and the diagnostic analysis indicates no system risk then a normal recovery can be initiated. There are no MCE anomalies that would lead directly to a safing.
**Figure 2:** Flow chart for problem diagnosis and recovery from HV shutdown due to bright object detection.

**MAMA HV turn off during ramping**

In the event of a MAMA HV turn off during ramping, the following status buffer messages would be sent (note these are for MAMA 1 - a similar set correspond to MAMA 2):

- **FSW# 131, NSSC1# 643 MAMA_MCP_CURRENT_LIMIT** triggered by MCP current out of limits PARAM (0ZZZ, HEX) ZZZ = MCP current which exceeded the limit
- **FSW#132, NSSC1# 644 MAMA_RED_LIMIT_EXCEEDED**
This is triggered by event counter limit exceeded PARAM \(0ZZZ, \text{HEX}) ZZZ = \text{Event counter value which exceeded limits}

- \text{FSW}\#134, \text{NSSC1}\# 646, \text{MAMA}\_\text{SECOND\_YELLOW\_LIMIT\_EXCEEDED}

This is triggered by a 2nd yellow limit violation of the event counter. The second value is collected after FSW waits for the yellow limit wait time after a first violation. It could also be due to a settling time problem with the MCP or Photocathode/Field values around the limits during ramp. In the event that a red or yellow limit is exceeded a check should be made to see if the event occurred near, or in SAA.

**HV shutdown due to out of limits**

A shutdown due to a voltage monitor limit violation is indicated by the telemetry keywords:

- \text{OMiMCPV} (MCP voltage) \([i=1 \text{ or } 2]\)
- \text{OM1FLDV} (MAMA 1 field voltage)
- \text{OM2PCV} (MAMA 2 PC voltage)

The following status buffer messages would be sent:

- \text{MAMA} 1 \text{FSW}\# 44, \text{NSSC1}\# 556 \text{MCE1\_VLTG\_MONITOR\_HVOFF}
- \text{MAMA} 2 \text{FSW}\# 46, \text{NSSC1}\# 558 \text{MCE2\_VLTG\_MONITOR\_HVOFF}

where the parameter values are

1. MCP [voltage] too low
2. MCP [voltage] too high
3. Field [voltage] too low
4. Field [voltage] too high

\(ZZZ = \text{[voltage] level which tripped limit}\)

In the case of a voltage monitor limit violation, it is probable that there was a hardware fault. Since overlight conditions can cause a voltage sag leading to a monitor violation, the condition should, however, be treated as a bright object violation until it can be proven that a hardware fault resulted in the fault.